INTERNATIONAL STANDARD

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Second edition
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Plastics — Determination of hardness —

Part 1:
Ball indentation method

Plastiques — Détermination de la dureté —

Partie 1: Méthode de pénétration à la bille

Reference number
ISO 2039-1:1993(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 2039-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Sub-Committee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 2039:1987), of which it constitutes a minor revision. A note has been added to 8.5 suggesting how to deal with warped test specimens. A note has also been added to the table in the annex, concerning the test load to be used in borderline cases. In addition, the text has been updated to bring it into conformity with current editorial style.

ISO 2039 consists of the following parts, under the general title *Plastics — Determination of hardness*:

— *Part 1: Ball indentation method*

— *Part 2: Rockwell hardness*

Annex A forms an integral part of this part of ISO 2039.

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Plastics — Determination of hardness —

Part 1:
Ball indentation method

1 Scope

This part of ISO 2039 specifies a method for determining the hardness of plastics and ebonite by means of a loaded ball indenter.

The ball indentation hardness determined by this method may provide data for research and development, quality control and acceptance or rejection under specifications.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 2039. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 2039 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 291:1977, *Plastics — Standard atmospheres for conditioning and testing.*

3 Definition

For the purposes of this part of ISO 2039, the following definition applies.

3.1 ball indentation hardness: The quotient of the load on the ball indenter by the surface area of the impression caused by the ball indenter after a specified time of load application. It is expressed in newtons per square millimetre.

4 Principle

The method consists of forcing a ball under a specified load into the surface of the test specimen. The depth of impression is measured under load. The surface area of the impression is computed from its depth. The ball indentation hardness is then calculated from the following relationship:

$$\text{Ball indentation hardness} = \frac{\text{Applied load}}{\text{Surface area of impression}}$$

5 Apparatus

5.1 The apparatus shall consist essentially of a frame with an adjustable platform fitted with a plate to support the test specimen, an indenter with its associated fittings and a device for applying the load without impact.

The apparatus shall be equipped with a device to measure the depth of penetration of the indenter with the accuracy indicated in 5.5.

The frame shall not be deformed under the maximum load by more than 0,05 mm, the deformation being measured along the main axis of the applied force.

5.2 The indenter shall be made from hardened steel and shall be polished. The ball shall not show any deformation or damage after the test.

The diameter of the ball shall be 5,0 mm ± 0,05 mm.

5.3 The initial load F_0 (tolerance ± 1 %) shall be 9,8 N.

5.4 The test load F_m (tolerance ± 1 %) shall have one of the following values:

49,0 N — 132 N — 358 N — 961 N

5.5 The depth measurement range of the apparatus shall be 0,4 mm, measurable to an accuracy of ± 0,005 mm.

5.6 **A timing device**, accurate to ± 0,1 s.

6 Test specimen

The test specimen shall be a smooth flat sheet or block of sufficient size to minimize the edge effect on the test result; for example 50 mm × 50 mm. The surfaces of the test specimen shall be parallel. A thickness of 4 mm is recommended.

The supported surface of the test specimen shall not show any deformation after testing.

7 Conditioning

The test specimens shall be conditioned, prior to testing, in accordance with ISO 291.

8 Procedure

8.1 Unless otherwise specified, carry out the tests in the standard atmosphere specified in ISO 291.

8.2 Place the test specimen on the supporting plate so that the test specimen is fully supported and its surfaces are perpendicular to the direction of the applied load.

Apply the initial load (see 5.3) so that the point of contact of the indenter is not less than 10 mm from the edge of the test specimen. Set the depth-indicating device to zero and then additionally apply the test load F_m (see 5.4). Carry out the loading without impact, over a period of 2 to 3 s.

8.3 Choose the test load F_m from the specified values to obtain a depth of impression between 0,15 mm and 0,35 mm.

If the values of the depth of impression after 30 s are outside this range (either in the case of a series of test specimens or in the case of an individual test specimen), change the test load to obtain the correct depth of impression. The number of test measurements which do not give the correct depths of impression shall be reported.

8.4 Carry out the test in such a manner that any bubbles or cracks in the test specimen do not influence the results. If several determinations are carried out on the same test specimen, ensure that the points of application of the indenter are not less than 10 mm apart from each other and from the edge of the test specimen.

8.5 After 30 s of application of the test load, F_m, measure the depth of impression under load, h_1, with the accuracy specified in 5.5.

NOTE 1 In some cases, it is difficult to obtain test specimens that are exactly flat. If such slightly warped test specimens are used, part of the measured "depth of impression" will in fact correspond to the distance travelled by the indenter in pressing the test specimen down on to the supporting plate. This difficulty can be overcome by using a supporting plate of diameter 10 mm ± 1 mm. This diameter is also sufficiently large for perfectly flat test specimens.

8.6 Make 10 valid tests on one or more test specimens.

8.7 Determine the deformation of the frame of the apparatus, h_2, in millimetres, as follows: Place a soft copper block (at least 6 mm thick) on the supporting plate and apply the initial load F_0. Set the depth-indicating device to zero and apply the test load F_m. Maintain the test load until the depth indicator is stationary. Note the reading, remove the test load and reset the depth indicator to zero.

Repeat this sequence of operations until the reading of the depth indicator is constant after each application of the test load. This represents the point at which no further penetration of the copper block takes place and therefore the constant depth reading is the movement of the depth-indicating device due to the deformation of the frame of the apparatus. Note this constant reading as h_2.

9 Expression of results

9.1 Calculate the reduced test load, F_r, in newtons, as follows:

$$F_r = F_m \times \frac{0,21}{(h - h_r) + 0,21}$$

where

F_m is the test load, in newtons, on the indenter;

h_r is the reduced depth of impression (= 0,25 mm);

h_1 is the depth of impression, in millimetres, under the test load on the indenter;

h_2 is the deformation, in millimetres, of the test apparatus under the test load;

h is the depth of impression, in millimetres, after correcting for the deformation of the frame (= $h_1 - h_2$).

NOTE 2 The value of h_r and the constants are taken from a paper by H.H. Racké and Th. Fett, *Materialprüfung,* **10** (1968) No. 7, p. 226.

9.2 Calculate the ball indentation hardness from the equation

$$H = \frac{1}{5\pi} \times \frac{F_r}{h_r}$$

where

H is the ball indentation hardness, in newtons per square millimetre;

F_r is the reduced test load, in newtons (see 9.1);

h_r is the reduced depth of impression, in millimetres.

9.3 For values of H lower than 250 N/mm^2, round off to the nearest 1 N/mm^2.

For values of H greater than 250 N/mm^2, round off to the nearest multiple of 10 N/mm^2.

10 Test report

The test report shall include the following particulars:

a) reference to this International Standard;

b) complete identification of the material tested;

c) conditioning and conditions under which the tests are carried out;

d) description, dimensions and manner of preparation of the test specimens;

e) number of tests averaged;

f) number of tests which resulted in incorrect depths of impression;

g) ball indentation hardness, average value and standard deviation.

Annex A
(normative)

Values of the ball indentation hardness as a function of the depth of penetration and the test load

Calculate the ball indentation hardness H using the formula

$$H = \frac{1}{5\pi} \times \frac{F_m}{h_r} \times \frac{0,21}{(h - h_r) + 0,21}$$

Table A.1

Depth of impression, h mm	Ball indentation hardness, H, (N/mm²) for F_m = 49,0 N	F_m = 132 N	F_m = 358 N	F_m = 961 N
0,150	23,84	64,35	174,0	467,2
0,155	22,80	61,56	166,4	446,9
0,160	21,85	58,99	159,5	428,3
0,165	20,98	56,63	153,1	411,1
0,170	20,17	54,45	147,2	395,3
0,175	19,42	52,44	141,8	380,7
0,180	18,73	50,56	136,7	367,1
0,185	18,08	48,82	132,0	354,4
0,190	17,48	47,19	127,6	342,6
0,195	16,92	45,67	123,5	331,6
0,200	16,39	44,24	119,6	321,2
0,205	15,89	42,90	116,0	311,5
0,210	15,42	41,64	112,6	302,3
0,215	14,98	40,45	109,4	293,7
0,220	14,57	39,33	106,3	285,5
0,225	14,17	38,26	103,5	277,8
0,230	13,80	37,26	100,7	270,5
0,235	13,45	36,30	98,2	263,6
0,240	13,11	35,39	95,7	257,0
0,245	12,79	34,53	93,4	250,7
0,250	12,49	33,71	91,2	244,7
0,255	12,20	32,93	89,0	239,0
0,260	11,92	32,18	87,0	233,6
0,265	11,65	31,46	85,1	228,4
0,270	11,40	30,78	83,2	223,4
0,275	11,16	30,12	81,5	218,7
0,280	10,93	29,50	79,8	214,1
0,285	10,70	28,89	78,1	209,8
0,290	10,49	28,32	76,6	205,6
0,295	10,28	27,76	75,1	201,6

Depth of impression, h mm	Ball indentation hardness, H, (N/mm²) for			
	F_m = 49,0 N	F_m = 132 N	F_m = 358 N	F_m = 961 N
0,300	10,08	27,23	73,6	197,7
0,305	9,89	26,71	72,2	193,3
0,310	9,71	26,22	70,9	190,4
0,315	9,53	25,74	69,6	186,9
0,320	9,36	25,28	68,4	183,6
0,325	9,20	24,84	67,2	180,3
0,330	9,04	24,41	66,0	177,2
0,335	8,89	24,00	64,9	174,2
0,340	8,74	23,60	63,8	171,3
0,345	8,60	23,31	62,8	168,5

NOTE — When the ball indentation hardness of a test specimen is in the transition zone between one test load and the next, slight differences in the ball indentation hardness may result if the test is carried out either with the smaller test load at a low depth of impression or with the larger test load at a high depth of impression. In such cases, it is recommended that the test load to be used be agreed upon between the interested parties.

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